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Effects of hydraulic installations on the prevalence of *Plasmodium falciparum* in the Logone plain in Far North region of Cameroun

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Abstract

The prevalence of *Plasmodium falciparum* was determined out on 420 persons in two villages of a hydro-arranged perimeter and two others out of the water intake perimeter in the Far North region in Cameroon. Thick and thin blood smears were stained with Giemsa. Species-specific densities of plasmodia were estimated under a light microscope at high magnification with thin blood smears for identification of parasite species and thick blood smears for densities by counting the number of parasites on the basis of 8,000 white blood cells / microlitre of blood. Results showed that persons of the hydro-arranged perimeter were significantly infected than those out of the hydro-arranged perimeter. In addition persons from 0 to 11 years were significantly more infected than others in the two perimeters. Females were significantly more infected than males in the hydro-arranged perimeter. With or without prevention persons of the hydro-arranged perimeter were significantly more infected than those out of the hydro-arranged perimeter. These results show the importance of the human plasmodia infections and its local variability. These informations were necessary to optimize methods of fight against *P. falciparum* in the Logone plain and in similar areas.

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Introduction

Malaria is the parasitic disease most widely spread in the world. It accounts for about 600 million clinical attacks and kills more than 2 million each year in the world (Chen *et al.,* 1998). Five Plasmodium species are involved in plasmodia infections namely *P. falciparum, P. vivax, P. ovale, P. malariae* and *P. knowlesi*. However, *P. falciparum* is the species most widely spread and responsible for most of the morbidities and for nearly the total mortalities assigned to malarial diseases (Genton *et al.,* 1994). In Sub-Saharan Africa, which is the most endemic area, P. falciparum species accounts for nearly one million deaths every year (Snow *et al.,* 2005). However, the epidemiology of this parasitic disease varies from one continent to another, from one locality to another and sometimes within the same village (Carnevale *et al.,* 1984; Mouchet *et al.,* 1993). Immunity and the dependent effects on the epidemiology of malaria in human populations depend on the level and the regularity of transmission (Smith *et al.,* 1999; Djaman *et al.,* 2002; Rogier, 2003).

In the Far North region of Cameroon, the National programme against malaria (PNLP) observed 47% of cases of malaria (light or severe) in 2008. In 1971, in the above region, the Cameroon government undertook hydro-installations to grow rice in this area. Localities involved in these hydraulic arrangements were those concerned with demographic and environmental changes and were therefore at high risk of health problems since a common feature of diseases especially parasitic infections is that they are most prevalent in developing world, particularly among the poorest groups in rural communities. Since individuals in such areas are often at an high risk of morbidity and because of climate and environmental changes that enhance parasitic diseases in the tropics, appraisal of the extent of haemoparasites especially plasmodia infections is a key measure of disease burden, and an important guide for sound control strategies. In the Logone plain, an investigation carried out by Josse *et al.* (1987) among children aged 2 to 9 years on malaria showed that the plasmodia indices doubled from one season to another, passing from 10.4 to 23.2% in the rice project zone and 19.1 to 40.7% in the bordering zone, during the dry season and the rainy season respectively.

The environmental change added to an epidemiologic context of already alarming malaria justifies the need for undertaking a comparative study to determine the prevalence of parasites such as *Plasmodium* sp and stratified according to seasons, age, sex and prevention in and out of a hydro-arranged perimeter. The aim of this study was to investigate the effects of hydraulic installations on the prevalence and intensity of human plasmodia reservoir in the Logone plain in Far North region of Cameroon.

Materials and methods

Study site

The study was conducted in the Logone plain located in the Far-North region of Cameroon. This region lies between geographical co-ordinates of 10° and 13° North and 13°15' and 15°45' East. It covers approximately an area of 34,263 km² at a lower elevation of 400 m above sea level (m.a.s.l) and borders Nigeria in the West and Chad in the East. (Criaud, 1986; Kuété *et al.*, 1993). The climate here is the soudano-sahelian type which is characterized by one rainy season from June to October with rainfall ranging from 500 to 900 mm with average between 750 to 800 mm and a long dry season from November to May. The average temperature is 28°C with a peak of 45°C between March and May (Criaud, 1986; Kuété *et al.*, 1993). In the study area, at the district of Maga, irrigation is practiced around an artificial lake for the growing of rice. The artificial lake has a water capacity ranging from 550 to 800 million cubic meters depending on seasons.

Population

The Far North region is one the most populated in Cameroon and the current population is estimated to be 3, 111 792 with a density of 90.8 / km² (Mbarga, 2010). The study is related to populations of 2 villages located in the hydro-arranged perimeter which extends on approximately 10 km around an artificial lake and 2 others from an area out of the hydro-arranged perimeter at a distance of 40 km from the artificial lake to avoid any direct influence of the latter. A radius of 15 km delimits the extent of the latter perimeter.

In the hydro-arranged zone, a list of 7 villages (whose population is estimated to be 8 100 inhabitants according to estimations of the traditional authorities) was made. After a random sampling, two villages were retained (Malawaye and Ziam I). Out of the hydro-arranged zone, a list of 6 villages (with the whole population estimated to be 6 500 inhabitants according to the traditional authorities) was made and two villages (Agamé and Goumlaye) were randomly drawn from the list. Malawaye, Ziam I, Agamé and Goumlaye are located at 0.4 km, 7 km, 61 km and 46 km from the artificial lake respectively. These villages have approximately 500, 700, 600 and 750 inhabitants respectively (according to the traditional authorities). In each village, a list of families was retained and the number of surveys were fixed in advance with 105 persons per village for the study. The families and individuals were drawn randomly. The study lasted from June 2009 to May 2011. The investigation and the determination of the prevalence of *P falciparum* took place each year during the rainy season (August 2009, August 2010) and during the dry season (February 2010, February 2011).

Sample collections

Finger prick blood samples were obtained and thick and thin blood films were prepared on microscope slides each year in August during the rainy season and in February from the same persons. Blood specimens were transferred to the laboratory in the towns of Maga and Moulvoudaye. Thick and thin blood smears were stained with Giemsa and analysed within 4 weeks. Species-specific densities of plasmodium were estimated under a light microscope at high magnification by counting the number of parasites. After examination of 100 microscopic fields per slide , these counts were converted to the number of parasites per µl of blood, assuming as standard a WBC (white blood cells) count of 8000/µl (WHO, 1993).

Statistics

The reduced variable ε was used to compare percentages. If $\varepsilon < 1.96$ the difference was not significant to 5%; if $\varepsilon \geq 1.96$ the difference was significant (Schwartz, 1996).

Results and discussion

Effects of seasons

During the rainy seasons, the prevalence of *P. falciparum* (Table 1) varied from 24.8 to 28.7% with an average of 26.7% in the hydro-arranged perimeter against 24.2 to 26.1% with an average of 25.2% out of the hydro-arranged perimeter. However, no significant difference ($\varepsilon = 0.56$; $p > 0.57$) was found between the two perimeters. Within the perimeters, no significant differences ($\varepsilon = 0.90$; $p > 0.37$; $\varepsilon = 0{,}45$; $p > 0.65$) were found respectively between localities of the hydro-arranged perimeter and those out the hydro-arranged perimeter. During dry seasons, the prevalence of *P. falciparum* (Table 1) varied from 26.2 to 27.4% with an average of 26.8% in the hydro-arranged perimeter against 12.4 to 16.7% with an average of 14.5% for the zone out of hydro-arranged perimeter. The prevalence of *P. falciparum* was significantly ($\varepsilon = 4.55$; $p < 0.001$) higher in the hydro-arranged perimeter. Within the perimeters, no significant differences ($\varepsilon = 0.27$; $p > 0.78$; $\varepsilon = 1.26$; $p > 0.21$) were found between localities in the hydro-arranged perimeter and those out of the hydro-arranged perimeter respectively. There was no significant difference ($\varepsilon = 0.03$; $p > 0.97$) between the two seasons within the hydro-arranged perimeter, but significant difference ($\varepsilon = 3.96$; $p < 0.001$) was found between the two seasons in the perimeter not involved. Prevalences during the rainy season in the two perimeters and those in the dry season in the hydro-arranged perimeter were almost similar to those in an agro-industrial complex in Cameroon in a study by Cot et al. (1992) who observed a prevalence of 29.2%. In this study prevalences were particularly lower during the dry season in the area out of the hydro -arranged perimeter. These results are different from those of Josse *et al,* (1987) who found prevalences of 10.4% in the rice project zone and 40,7% in the bordering zone among children aged 2 to 9 years. In the rainy seasons, conditions are favorable for the proliferation of P. falciparum vectors in the two perimeters. During dry seasons, because of dessication and lack of swampy areas, eggs and larvae of these vectors are destroyed in the no water catch Perimeter, while they are almost maintained the whole year in the hydro-arranged perimeter. Favourable conditions during rainy seasons could explain the levels of transmission and the absence of significance observed in both perimeters. On the other hand, unfavourable conditions could equally explain the level of transmission observed in the area out of the hydro-arranged perimeter and the significance difference between the two areas. These results are in agreement with those of Delmont (1982) who concluded that in the soudano-sahelian savanna region, prevalence of malaria fluctuates with the density of anopheles that is not stable due the variability of climatic conditions. Several studies (Chouaibou et al., 2006; Couprie et al., 1985; Kollo et al., 2001; Mouchet and Rageau, 1964) have come with the conclusion that An. gambiae and An. funestus are the main malarial vectors in the area. Geometric distributions of these vectors could be related to climatic changes on the environment. In addition, a hydro-installation, because of the permanent water, would change the transmission of the parasite from seasonal to perennial (Poda, 2007).

Table 1. Prevalence (%) of *P. falciparum* according to seasons, age and sex in the Logone plain (August 2009-February 2010 and August 2010-February 2011)

	Village		**Season**		**Age (years)**				**Sex**		**Total**
			Rain	Dry	[0 -11]	[12-24]	[25-44]	≥45	M	F	
PHA	Malawaye	N	209	208	140	104	114	59	172	245	417
		n	60	57	54	23	29	11	42	75	117
		P(%)	28.7	27.4	38.6	22.1	25.4	18.6	24.4	30.6	28.0
	Ziam I	N	209	206	77	56	170	112	187	228	415
		n	52	54	30	17	32	27	40	66	106
		P(%)	24.8	26.2	39.0	30.4	18.8	24.1	21.4	28.9	25.5
	Malawaye + Ziam I	N	418	414	217	160	284	171	359	473	832
		n	112	111	84	40	61	38	82	141	223
		P(%)	26.7	26.8	38.7	25.0	21.4	22.2	22.8	29.8	26.8
PNA	Agamé	N	210	209	144	124	104	47	223	196	419
		n	51	26	42	19	10	6	42	35	77
		P(%)	24.2	12.4	29.2	15.3	9.6	12.8	18.8	17.9	18.3
	Goumlaye	N	210	209	108	123	128	60	200	219	419
		n	55	35	31	24	24	11	50	40	90
		P(%)	26.1	16.7	28.7	19.5	18.8	18.3	25.0	18.3	21.4
	Agamé + Goumlaye	N	420	418	252	247	232	107	423	415	838
		n	106	61	73	43	34	17	92	75	167
		P(%)	25.2	14.5	28.9	17.4	14.6	15.8	21.7	18.0	19.9
	Total	N	838	832	464	407	516	278	782	888	1670
		n	218	172	157	83	95	55	174	216	390
		P(%)	26.0	20.6	33.8	20.3	18.4	19.7	22.2	24.3	23.3

PHA: hydro-arranged perimeter; PNA: perimeter not involved; N: number of examined persons; n: number of parasitized persons; P(%): prevalence; M: masculine; F: female.

Effects of age

In the hydro-arranged perimeter, the prevalence of *P falciparum* (Table 1) varied from 38.6 to 39.0% with an average of 38.7% in persons from 0 to 11 years; 22.1 to 30.4% with an average of 25.0% in persons from 12 to 24 years; 18.8 to 25.4% with an average of 21.4% in persons from 25 to 44 years and 18.6 to 24.1% with an average of 22.2% in 45 years old and above. Out of the hydro-arranged perimeter, the prevalence of *P. falciparum* varied from 28.7 to 29.2% with an average of 28.9% in persons from 0 to 11 years; 15.3 to 19.5% with an average of 17.4% in persons from 12 to 24 years; 9.6 to 18.8% with an average of 14.6% in persons from 25 to 44 years and 12.8 to 18.3% with an average of 15.8% in 45 year old persons and above. Persons from 0 to 11 years were significantly ($\varepsilon = 2.91$; $p < 0.001$) more infected in the hydro-arranged perimeter and out of the hydro-arranged perimeter ($\varepsilon = 3.10$; $p < 0.001$) than those of other age classes (Table 1). This situation could be explained by the brittleness of immunity in this group of age, compared to adults whose immunities are matured. In endemic areas, age could be a factor of the maturity of the immune system (Hannet *et al.*, 1992). According to Rogier *et al.* (2009), the prevalence of the plasmodia infections decreases with the increase in the level of immunity.

Table 2. Prevalence (%) of *P. falciparum* according to prevention in the Logone plain (August 2009- February 2010 and August 2010 and February 2011).

	Village		Prevention: No	Prevention: YES
PHA	Malawaye	N	30	387
		n	14	103
		P(%)	46.6	26.6
	Ziam I	N	4	411
		n	3	103
		P(%)	75.0	25.1
	Malawaye + Ziam I	N	34	798
		n	17	206
		P(%)	50.0	25.8
PNA	Agamé	N	141	419
		n	38	77
		P(%)	27.0	18.4
	Goumlaye	N	198	419
		n	58	90
		P(%)	29.3	21.5
	Agamé + Goumlaye	N	339	838
		n	96	167
		P(%)	28.3	19.9
	Total	N	373	1636
		n	113	373
		P(%)	30.2	22.7

PHA: hydro-arranged perimeter; PNA: perimeter not involved; N: number of examined persons; n: number of parasitized persons; P(%): prevalence.

Effects of sex

In the hydro-arranged perimeter, the prevalence of *P. falciparum* according to sex (Table 1) varied from 21.4 to 24.4% with an average of 22.8% in males against 28.9 to 30.6% with an average of 29.8% in females. In the hydro-arranged perimeter, the prevalence varied from 18.8 to 25.0% with an average of 21.7% in males against 17.9 to 18.3% with an average of 18.0% in females. The prevalence of *P. falciparum* according to sex (Table 1) shows that in the hydro-arranged perimeter females were significantly ($\varepsilon = 2.33$; $p < 0.02$) more infected than males, while in the area out of the hydro-arranged perimeter there was no significant difference ($\varepsilon = 1.37$; $p > 0.17$) between males and females. The difference between males and female in the hydro-arranged perimeter could be explained by immunity related to sex in an area where the level of transmission of the parasite is high. Indeed, females are susceptible to risk factors such as pregnancy. During pregnancy, immunity against malaria decreases after the first three months of pregnancy, which make them more vulnerable (Rogier *et al.*, 2009).

Effects of prevention

In the hydro-arranged perimeter, the prevalence of *P. falciparum* in individuals who did not do the prevention (Table 2) varied from 46.6 to 75.0% with an average of 50.0% against 27.0 to 29.3% with an average of 25.8% out the hydro-arranged perimeter. In addition, the prevalence of *P. falciparum* in individuals who did the prevention varied from 25.1 to 26.6% with an average of 25.8% in the hydro-arranged perimeter against 14.0 to 14.5% with an average of 19.9% out the hydro-arranged perimeter . The prevalence of *P. falciparum* in individuals who do not prevent malaria (Table 2) shows that, the latter are significantly ($\varepsilon = 2.43$; $p < 0.02$) more infected in the hydro-arranged perimeter. In the same way, those who prevent the disease are significantly ($\varepsilon = 2.95$; $p < 0.009$) more infected in the hydro-arranged perimeter than those out of the hydro-arranged perimeter. Under the same conditions of prevention against the parasite, individuals of the hydro-arranged perimeter are more vulnerable. This could be explained by environmental conditions that are more favorable to the transmission of *P. falciparum*. Poda (2007) mentioned that the only fact of living in contact with water and hydro-installations supports the infestation by the parasite.

Results from this study show that individuals in the hydro-arranged perimeter are significantly more infected than those in the perimeter not involved during the dry season. In addition individuals from 0 to 11 years are significantly more infected in the two perimeters than others. With or without preventions individuals of the hydro-arranged perimeter are more infected than those out of the area. These results show the importance of the human plasmodia and its local variability. These informations were necessary to optimize methods of fight against *P. falciparum* in the Logone plain and similar areas.

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